Survey of Northern Abalone, *Haliotis kamtschatkana,* Populations at Chrome Island and southern Denman Island, May – June 2000 and May 2001

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V9T 6N7

2002

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2624

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103-02752/

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2624

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SURVEY OF NORTHERN ABALONE, *Haliotis kamtschatkana*, POPULATIONS AT CHROME ISLAND AND SOUTHERN DENMAN ISLAND, MAY - JUNE 2000 AND MAY 2001

by

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Cat. No. Fs 97-4/2624E ISSN 0706-6473

Correct citation for this publication:

Lucas, B.G., A. Campbell and D. Brouwer. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations at Chrome Island and southern Denman Island, May – June 2000 and May 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2624: 13 p.

ABSTRACT

Lucas, B.G., A. Campbell, and D. Brouwer. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations at Chrome Island and southern Denman Island, May – June 2000 and May 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2624: 13 p.

A survey was conducted to provide an estimate of population numbers of emergent northern abalone in areas known to have abalone present at Chrome Island and southern Denman Island, British Columbia, during May 30 to June 2, 2000 and on May 29, 2001. Abalone shell lengths (SL) ranged from 26 to 137 mm SL. The estimated mean density for abalone of all sizes was 0.06/m^2, and for abalone 90 – 110 mm SL was 0.02/m^2. The estimated mean total population number (and 90% confidence interval) of emergent abalone for all sizes was 14,734 (7,868 – 21,601), and for 90 – 110 mm SL abalone was 4,820 (1,577 – 8,062). The highest density for all sizes of abalone in a transect was 0.23/m^2, and for abalone 90 – 110 mm SL was 0.10/m^2.

RÉSUMÉ

Lucas, B.G., A. Campbell, and D. Brouwer. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations at Chrome Island and southern Denman Island, May – June 2000 and May 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2624: 13 p.

Notre relevé avait pour but d'estimer l'effectif de la population d'ormeaux nordiques exondés dans des régions où la présence de ce mollusque est connue, à l'île Chrome et au sud de l'île Denman (Colombie-Britannique), du 30 mai au 2 juin 2000 et le 29 mai 2001. La longueur de la coquille des ormeaux (LS) allait de 26 à 137 mm. La densité moyenne des ormeaux de toutes les tailles a été estimée à 0,06/m^2, et, pour les spécimens de 90 – 110 mm LS, à 0,02/m^2. L'effectif total moyen de la population (avec intervalle de confiance à 90 %) d'ormeaux exondés, toutes tailles confondues, était de 14 734 (7 868 – 21 601), et pour les ormeaux de 90 – 110 mm LS, de 4 820 (1 577 – 8 062). La densité la plus forte, toutes tailles confondues, relevée dans un transect était de 0,23/m^2, et pour les ormeaux de 90 – 110 mm LS, de 0,10/m^2.

INTRODUCTION

Northern abalone, *Haliotis kamtschatkana*, populations have declined in British Columbia (B.C.), despite complete closure of the fishery since 1990 for conservation purposes. Post-harvest surveys indicated that abalone densities were well below levels recommended to ensure sustainable populations (Breen 1986, Campbell et al. 1998). The future of *H. kamtschatkana* was sufficiently uncertain that in April 1999 this species was declared "Threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada).

Fisheries and Oceans Canada (DFO), in cooperation with coastal communities and other interested stakeholders, has begun an initiative to rehabilitate abalone stocks in B.C. Collection of broodstock will be required to implement the first step in this program, which is to develop aquaculture technology for this species.

To estimate the abundance of abalone stocks in areas of interest, an independent assessment using conventional survey methodology was required. Only emergent (visible) abalone were surveyed to provide a minimum estimate of mature adult population numbers; cryptic abalone were not surveyed in this census.

The objectives of this study were to estimate densities, size frequencies, and population numbers of emergent northern abalone at Chrome Island and southern Denman Island.

MATERIALS & METHODS

FIELD METHODS

Surveys were conducted during May 30 to June 2, 2000 and on May 29, 2001, at Chrome Island and southern Denman Island, B.C. (Figure 1). Fifteen transects were surveyed at Chrome Island and nearby on southern Denman Island in 2000. In 2001, six transects were surveyed in a contiguous area just northward on southeastern Denman Island. The transect survey method (Cripps and Campbell 1998) was used for this study. Transects were randomly placed along the lengths of shoreline where populations were to be estimated. To avoid bias, these transect positions were determined in advance. The primary sampling unit was a "transect", made up of a cluster of secondary units, or quadrats. Each transect was 1 m wide and variable in length, depending on the slope of the substrate. Prior to entering the water, a lead line was laid perpendicular to shore from the boat in depths of approximately 12 m to 0 m from datum. The secondary sampling unit consisted of a 1 m x 1 m square quadrat that was placed along the transect, 1 m away, to avoid sampling areas disturbed by the lead line placement. Divers flipped the quadrat parallel to the transect line, from deep to shallow, and the number of "emergent" or "exposed" abalone, shell length (SL in mm) of each abalone, depth, substrate type, slope, and algal cover was recorded. Algal cover, sea urchins and starfish were removed from the quadrat to ensure all emergent abalone were detected. Boulders were not moved to search for cryptic abalone, since the majority of mature animals (i.e., ≥ 70 mm SL) are exposed (Campbell 1996).

Every second quadrat was surveyed on all but one transect, where every third quadrat was surveyed on a portion of the transect.

ANALYTICAL METHODS

All gauge depths were converted to depth (m) at chart datum. The survey results were analyzed according to Fisheries and Oceans Canada methodology (Campbell et al. 1999). To determine the size frequency distribution for a location, the number of abalone in each 5 mm SL size class was divided by the total number of abalone in each location.

The estimated mean density, $\bar{d}$ (number/m^2), of abalone was calculated as:

$$\bar{d} = \frac{\sum_t (d_t * L_t)}{\sum_t L_t} \qquad (1)$$

where d_t is the mean density (number of abalone counted/number of quadrats surveyed) at transect t, and L_t is the length of transect t.

The standard error of the mean density, se_d, was calculated as:

$$se_d = \sqrt{1-\frac{n}{T}} * \sqrt{\frac{\sum_t (d_t * L_t - \bar{d} * L_t)^2}{n*(n-1)*\bar{L}^2}} \qquad (2)$$

where n is the number of transects, T is the total possible number of transects that can be sampled in the surveyed area, and $\bar{L} = \frac{\sum_t L_t}{n}$ is the mean transect length. The expression $\sqrt{1-\frac{n}{T}}$ is approximately one, because the sample size n is small compared to T. This method accounts for the variable length of transects and for the variable proportion of quadrats surveyed along each transect.

To estimate the mean density for a specific size group (J), (e.g., 90 – 110 mm SL) the value d_t was substituted with densities ($P_{t,J}$) in equations 1 and 2. The mean density $P_{t,J}$ of abalone of size group J in transect t was calculated as:

$$P_{t,J} = \frac{\left(N_t * \frac{\sum_{i \in J} m_{t,i}}{M_t} \right)}{S_t} \qquad (3)$$

where J is a subset (e.g., 90 – 110 mm SL) of possible i values representing a range of shell lengths (SL_i), S_t is the number of quadrats surveyed for density estimates in transect t, N_t is the number of abalone counted in transect t, $M_t = \sum_i m_{t,i}$ the total number of abalone measured in transect t, and $m_{t,i}$ is the number of abalone in size range J of transect t.

The approximate 90% confidence interval of the mean density (90CI) was calculated as:

$$90CI = \bar{d} \pm t_{\alpha/2} \cdot se_d \qquad (4)$$

where $t_{\alpha/2}$ is the critical t-distribution value at degrees of freedom of n-1.

The total number of abalone (X) and 90% confidence interval in each location was calculated as:

$$X = \bar{d} \cdot A \quad (L90CI \cdot A - U90CI \cdot A) \qquad (5)$$

where L90CI is the lower and U90CI is the upper 90% confidence interval of the mean density for all sizes or for a particular size group of abalone, and A is the estimated area (m^2) of the surveyed location. The area of the location surveyed was calculated as the product of the mean transect length (since transects generally covered the breadth of suitable abalone habitat) and the length of the location as measured by the distance the between the two furthest shoreline points used when generating random transects.

RESULTS

All areas of Chrome Island and southern Denman Island surveyed in 2000 and 2001 were moderately exposed to wind and storms. The substrate consisted of boulders, cobble, gravel and bedrock, with some sand and shell (Table 1). The slope of the substrate (angle from horizontal) estimated by divers ranged from 5° to 25°. In most transects no algal canopy was present, with only five transects having a limited canopy of *Nereocystis* and *Sargassum*. The predominant understory species in the 2000 survey was *Sargassum*, followed by *Agarum*, while *Laminaria* was most dominant in the 2001 survey. *Ulva* was the most common turf algae in the 2000 survey, while an unknown brown film and *Sargassum* were most common in 2001. Encrusting corraline algae were abundant as bottom cover in both the 2000 and 2001 surveys.

The depths for the 2000 survey ranged from –1.04 to 21.13 m and from -0.34 to 9.94 m in 2001 from datum (Table 2). In all surveys combined, 49 abalone were counted in quadrats along 21 transects, where the mean transect length was 82.29 m (Tables 2, 3). The 2000 survey had 40 abalone in 15 transects, where the mean transect length was 91.00 m. The 2001 survey had 9 abalone in 6 transects, where the mean transect length was 60.50 m. Overall eleven transects surveyed (52%) had no emergent abalone, while in the 2000 survey 8 transects (52%) had no emergent abalone and 3 transects (50%) were without emergent abalone in 2001. The maximum density of emergent abalone on a transect during both the 2000 and 2001 survey was

0.23 abalone/m^2. In all surveys combined and in the 2000 survey the highest concentration for abalone 90 – 110 mm SL in a transect was 0.10/m^2 while in 2001 the highest was 0.05/m^2.

Sizes of abalone for all surveys combined and for the 2000 survey ranged from 26 to 137 mm SL and from 81 to 115 mm SL in 2001 (Figure 2). The mean size of emergent abalone was 87 mm SL in all surveys combined, 83 mm SL in the 2000 survey, and 106 mm SL in 2001.

Estimated total mean density for abalone of all sizes was 0.06/m^2 in all surveys combined, 0.06/m^2 in the 2000 survey, and 0.05/m^2 in 2001 (Table 4). The mean population estimate of emergent abalone (and 90% confidence interval) was 14,734 (7,868 – 21,601) in all surveys combined, 7,351 (3,344 – 11,358) in the 2000 survey, and 5,216 (-770 – 11,403) in 2001. Abalone in the 90 – 110 mm SL size range had an estimated mean density of 0.02/m^2 in all surveys. The mean estimate of the number of abalone (and 90% confidence interval) in the 90 – 110 mm SL size range was 4,820 (1,577 – 8,062) in all surveys combined, 2,393 (397 – 4,388) in the 2000 survey, and 1,778 (200 – 3,357) in 2001.

DISCUSSION

The large difference in mean size of abalone between the two areas surveyed (2000 vs. 2001) may be the result of natural size variation within the population or an artifact of random sampling and the small sample size (i.e., 6 transects in 2001). Other possible causes include differences in food, habitat (Sloan and Breen 1988), or past harvesting. Differences in algal communities, such as was found in the two areas, can affect growth rates and maximum sizes (Breen and Adkins 1979). The area surveyed in 2001 was predominantly *Laminaria*, whereas *Sargassum* dominated the area surveyed in 2000. More intensive harvesting before the abalone closure or poaching of abalone thereafter may also have reduced the number of larger abalone in the area surveyed in 2000.

A conservative estimate of the total population numbers of emergent abalone of all sizes was provided by the lower 90% confidence interval (L90CI) for the mean, which was 7,868 for all surveys combined, 3,344 abalone for the 2000 survey and 0 in 2001. The L90CI for mature emergent abalone 90 – 110 mm SL was 1,577 for all surveys combined, 397 for the 2000 survey, and 200 in 2001. The large uncertainty surrounding the estimated population means resulted, in part, from the small sample sizes. The lower confidence intervals provided more conservative estimates of population size than the mean estimates.

This survey provides no evidence of recovery of abalone populations since the province-wide closure in 1990. Since no other abalone surveys have been conducted in the Chrome and southern Denman Island areas, comparisons were made with the Malcolm Island area, which is also located east of Vancouver Island on British Columbia's south coast. The total abalone densities found during the surveys at Chrome Island and southern Denman Island were slightly higher than those found in the Malcolm Island area in 1999 (0.05/m^2, 0.04/m^2, and 0.03 /m^2 at Cormorant Island, Bere Bay, and Trinity Bay respectively) (Lucas et al. 2002a). However, all areas surveyed still had low densities similar to other recent surveys in B.C. (Campbell et al.

1998; Lucas et al. 2002b, c). Since these low densities are well below those recommended to ensure sustainable populations (Breen 1986), the removal of any abalone from these areas must be considered with caution.

ACKNOWLEDGMENTS

We thank the Powell River Community Futures Development Corporation for their assistance with this study; M. Biagi, L. Delmistro, R. Gilham, J. Harding, M. MacNab, and J. Wegner for diving; B. Stonehouse for boat operations and dive tending; P. Ridings and D. Lis for assistance with figures and tables; D. Bureau for reviewing the manuscript.

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Table 1. Habitat summary for abalone transects surveyed at Chrome Island and southern Denman Island, May to June 2000 and May 2001. The most common substrates are listed (1 = first, 2 = second, 3 = third) where substrate code 1 = smooth bedrock, 2 = bedrock with crevices, 3 = boulders, 4 = cobble, 5 = gravel, 6 = pea gravel, 7 = sand. The algae present are listed by growth characteristic for the most common (Sp 1) and second most common (Sp 2) species with the percentage of cover (%) for each, where AG = *Agarum*, BG = brown grunge, CO = *Costaria*, DM = *Desmarestia*, EN = encrusting corraline, F = *Fucus*, GI = *Gigartina*, IR = *Iridaea*, LA = *Laminaria*, NT = *Nereocystis*, R = red algae, SA = *Sargassum*, and UL = *Ulva*.

						Algae													
		Substrate			Slope	Canopy				Understory				Turf				Bottom cover	
Transect	Date	1	2	3	degrees	Sp 1	%	Sp 2	%	Sp 1	%	Sp 2	%	Sp 1	%	Sp 2	%	Sp	%
2000 Survey																			
15	May 30	3	4	5	5					DM	10	CO	10					EN	80
114	May 31	3	4	7	10					AG	50	LA	50	SA	40	DM	5		
142	May 31	4	7		15														
149	June 01	3	4		15					SA	10			AG	20	GI,F	5	EN	15
152	May 30	3	4	5	15	SA	20	NT	10	NT,LA	20	SA	30	SA	10	LA	10	EN	20
164	June 01	4	5		5					AG	30							EN	20
167	June 01	4	5	7	5					AG	90			R	30	SA	5		
179	June 01	4	7		10					AG	35	LA	30					EN	5
185	May 30	2	4		6					SA	1	CO	1	NT	10	LA	10	EN	80
234	May 31	4	5	6	5					CO	5	LA	5	UL	2				
292	May 31	4	6	7	25									UL	2			EN	30
330	June 02	3	4	7	15					SA	5			R	30			EN	30
336	June 01	3	4	5	15	SA	5			SA	15			AG	10	UL	10	EN	20
340	June 02	3	6		10					SA	50			GI,IR	5	R	50	EN	100
346	June 01	3	4	7	10	NT	10	SA	10	SA	20	NT	5	UL,DM	10	AG,IR	5	EN	50
2001 Survey																			
8	May 29	5	3	4		NT	5			LA	15	DM	10					EN	10
9	May 29	4								SA	8			BG					
11	May 29	5	4	6										BG					
15	May 29	7	6	3		NT	1			LA	30	CO	2	SA	2				
16	May 29	1	2	4						UL	15	CO	5	SA	5			EN	10
18	May 29	5	4	6						LA		GI		UL				EN	

Table 2. Dive summary for abalone transects surveyed at Chrome Island and southern Denman Island, May 30 to June 2, 2000 and May 29, 2001.

		Time			Depth (m)		Number of	Transect	Number of Abalone		Density (#/m2)	
Transect	Date	Start	Finish	Bottom	Min	Max	Quadrats	Length (m)	all sizes	90-110mm	all sizes	90-110mm
2000 Survey												
15	May 30	11:16	13:30	2:14	1.10	5.88	92	183	10	5	0.11	0.05
114	May 31	12:08	12:20	0:12	2.93	21.13	36	71	0	0	0.00	0.00
142	May 31	12:50	13:05	0:15	2.29	14.30	31	61	0	0	0.00	0.00
149	June 01	10:01	10:36	0:35	2.13	8.78	41	81	0	0	0.00	0.00
152	May 30	13:57	14:30	0:33	-0.76	9.63	47	93	4	2	0.09	0.04
164	June 01	11:06	11:26	0:20	4.63	11.22	51	101	0	0	0.00	0.00
167	June 01	11:49	12:18	0:29	2.56	9.27	51	101	0	0	0.00	0.00
179	June 01	12:33	13:15	0:42	3.47	10.73	35	69	0	0	0.00	0.00
185	May 30	14:54	15:35	0:41	-0.70	11.52	25	49	4	0	0.16	0.00
234	May 31	10:43	11:06	0:23	1.25	12.16	38	75	0	0	0.00	0.00
292	May 31	11:30	11:52	0:22	2.13	11.61	32	63	0	0	0.00	0.00
330	June 02	11:10	11:50	0:40	0.85	10.27	55	109	3	0	0.05	0.00
336	June 01	15:25	16:00	0:35	0.09	8.84	48	95	11	5	0.23	0.10
340	June 02	9:50	10:30	0:40	-1.04	11.34	58	115	5	1	0.09	0.02
346	June 01	13:42	14:30	0:48	1.40	10.24	50	99	3	0	0.06	0.00
2001 Survey												
8	May 29	12:01	12:50	0:49	-0.24	5.00	28	55	0	0	0.00	0.00
9	May 29	15:00	15:45	0:45	4.11	9.94	22	43	5	1	0.23	0.05
11	May 29	13:42	13:54	0:12	2.65	8.35	24	47	0	0	0.00	0.00
15	May 29	11:45	12:59	1:14	2.56	8.66	37	73	0	0	0.00	0.00
16	May 29	14:27	15:15	0:48	-0.34	9.05	38	75	2	1	0.05	0.03
18	May 29	13:20	14:35	1:15	2.90	9.11	35	70	2	1	0.06	0.03

Table 3. Summary statistics of transect survey of emergent abalone from Chrome Island and southern Denman Island in 2000 and 2001. Values in brackets are standard errors.

Details per transect	S. Denman & Chrome Is.	S. Denman Is.	S. Denman & Chrome Is.
Dates	May 30 - June 2, 2000	May 29, 2001	May 30 - June 2, 2000 & May 29, 2001
Number of transects	15	6	21
Mean transect length (m)	91.00 (6.98)	60.50 (5.70)	82.29 (6.78)
Mean number of quadrats	46.00 (3.49)	30.67 (1.51)	41.62 (3.39)
Mean minutes/transect	37:56 (5:58)	50:30 (4:49)	41:31 (5:41)
Mean minutes/quadrat	0:48 (0:05)	1.37 (0.08)	1:02 (0:07)
Shoreline distance (m)	1392	1800	3192
Area surveyed (m^2)	126,672	108,900	262,656

Table 4. Mean densities (number/m^2) and population estimates of emergent abalone from Chrome Island and southern Denman Island, 2000 and 2001. Values in brackets are 90% confidence intervals.

Details per location	S. Denman & Chrome Is.	S. Denman Is. 2001	S. Denman & Chrome Is.
Dates	May 30 - June 2, 2000	May 29, 2001	May 30 - June 2, 2000 & May 29, 2001
Mean density all sizes	0.06 (0.03 - 0.09)	0.05 (-0.01 - 0.10)	0.06 (0.03 - 0.08)
Mean density 90 - 110 mm SL	0.02 (0.00 - 0.03)	0.02 (0.00 - 0.03)	0.02 (0.01 - 0.03)
Total population all sizes	7351 (3344 - 11358)	5216 (-770 - 11403)	14734 (7868 - 21601)
Population 90 - 110 mm SL	2393 (397 - 4388)	1778 (200 - 3357)	4820 (1577 - 8062)

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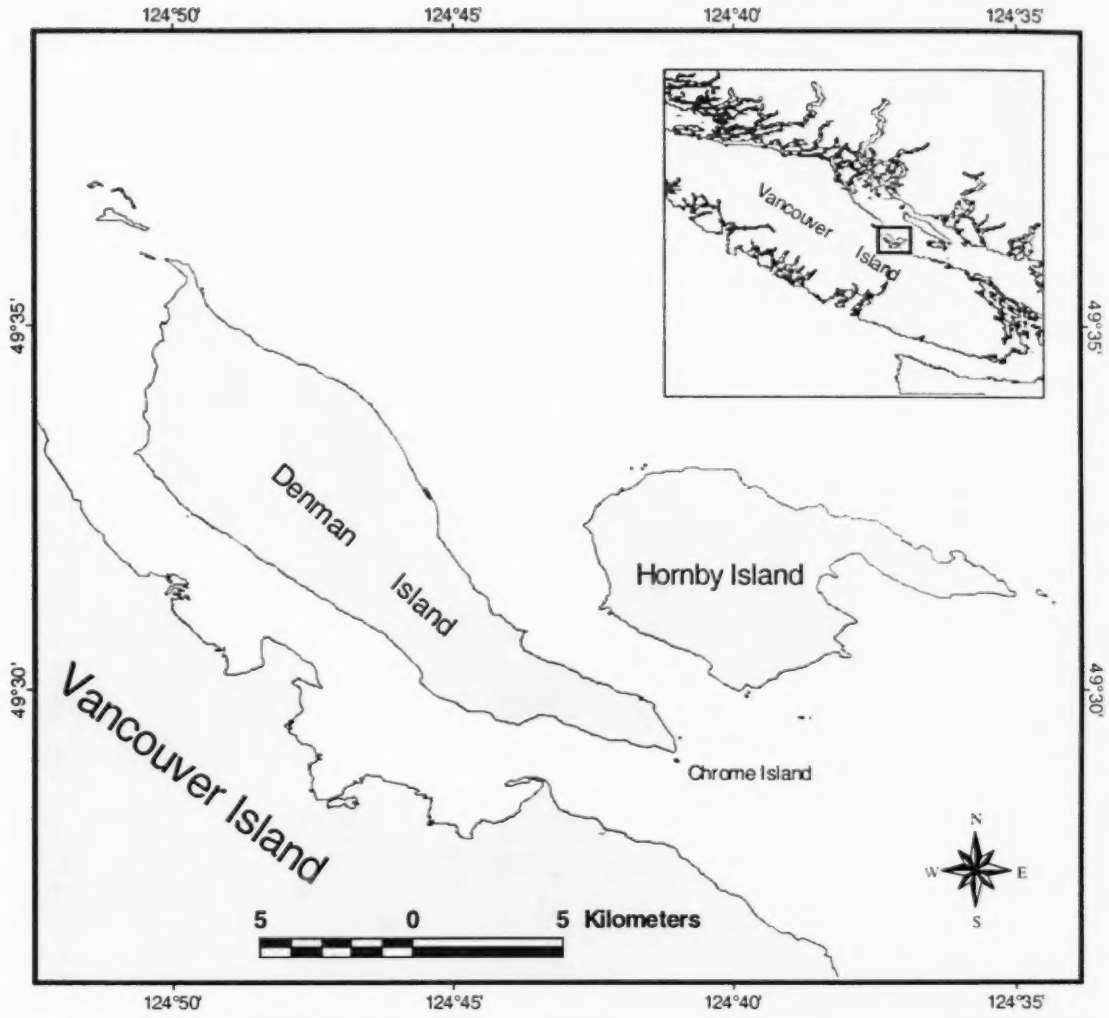

Figure 1. Abalone were surveyed at Chrome Island and southern Denman Island, May – June 2000 and May 2001. The inset shows the region of detail on Vancouver Island, British Columbia.

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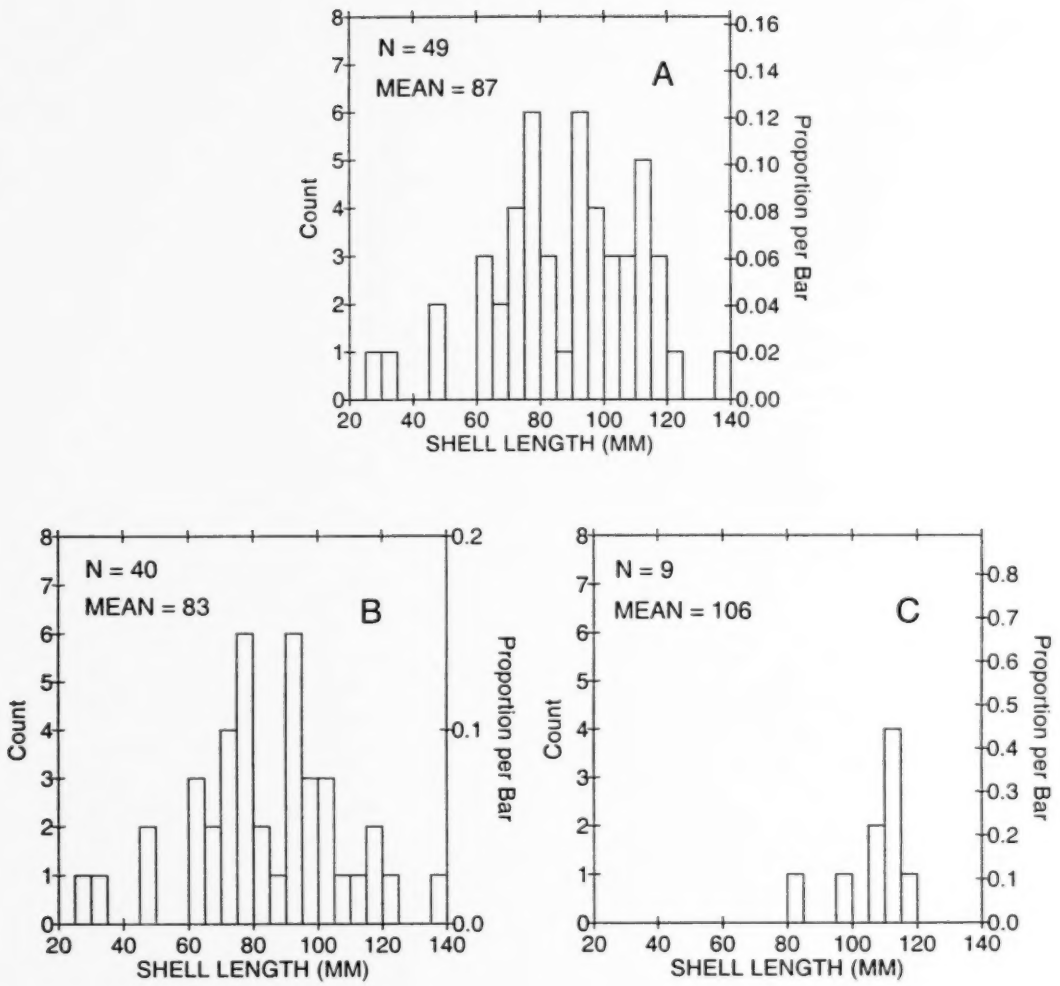

Figure 2. Size frequencies of emergent abalone found in quadrats during dive surveys at Chrome Island and southern Denman Island in 2000 and 2001 are shown for A) both surveys combined, B) 2000 survey, and C) 2001 survey. Number of abalone (N) and mean shell length in mm are shown.